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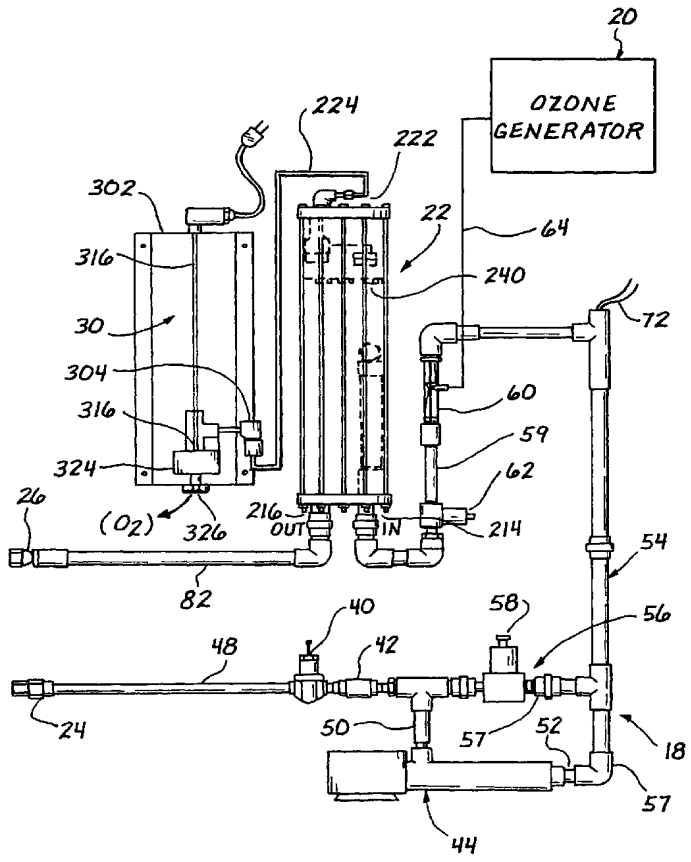
(54) Title: SPRAY APPARATUS FOR PROVIDING AN OZONE/AQUEOUS STREAM



(57) Abstract: A mobile ozonated aqueous spray apparatus having a pump (44), a regulator (40), a check valve (42), a bypass (57), a bypass valve (58), a venturi injector (60), a flow switch (72), a degas chamber (22), an ozone destruct assembly (30), an ozone generator (20), and a spray nozzle (30).

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SPRAY APPARATUS FOR PROVIDING AN OZONE/AQUEOUS STREAM

Background of the Invention

The present invention generally relates to apparatus for sanitizing articles and more specifically relates to apparatus for sanitizing articles using ozone as a sanitizing agent.

Ozone is a form of oxygen that exists as an unstable blue gas. It has been found to be an effective oxidizing agent, and has been used for the purification of drinking water, in industrial waste treatment, for deodorizing air and sewage gases, as a bleach for waxes, oils, and textiles, and as an oxidizing agent in chemical processes.

Furthermore, in sufficient concentrations, ozone is known to destroy bacteria, viruses and other microorganisms. Various devices and processes have been developed for disinfecting and sanitizing air and surfaces using ozone gas or ozonated water. Ozonated water can be used for sanitizing surfaces without heat treatment and without the use of potentially harmful chemicals. For example, beverage bottles can be rinsed with ozonated water prior to filling. Unlike many other sanitizing/disinfecting rinse agents, an ozone/aqueous rinse does not leave behind a residue that would later need to be removed from the treated surface.

Unfortunately, the use of ozone for sanitizing/disinfecting can be problematic. Although low concentrations of ozone gas have been used for deodorizing air for example, more substantial quantities and concentrations of ozone are required for sanitation or sterilization of surfaces. In addition, because ozone breaks down quickly it therefor should be generated at the site it is to be used, and should be used as it is being

generated. This factor limits the use of ozone for sanitation in many settings where physical space size is a consideration. In addition, the process of generating ozone presents health risks when persons are exposed to relatively high concentrations of the gas over a period of time. For example, prolonged exposure to ozone gas has been known to produce adverse symptoms such as irritation to the eyes, nose and throat, in humans and other mammals.

It would be highly beneficial to have a versatile, preferably portable, apparatus which safely uses ozone as a sanitizer, for example, in the agricultural industry.

Summary of the Invention

New systems and apparatus for effectively and safely providing a sanitizing dose of ozone in an aqueous stream have been discovered. The systems and apparatus of the present invention overcome one or more of the inadequacies of conventional devices and processes for using ozone as a sanitizing agent. The systems are straightforward in design and construction, preferably are sized and adapted to be portable, to increase flexibility and usefulness and do not rely on complicated controls and monitors for effective, safe operation.

In one broad aspect of the invention, ozonated water spray apparatus in accordance with the invention comprise a housing; an inlet on the housing, the inlet adapted to receive a flow of water from a pressurized water supply; an ozone generator, preferably a corona discharge ozone generator to provide increased concentrations of ozone, disposed within the housing and adapted to produce a stream of ozone-containing gas; and an injection assembly, for example a venturi injector, preferably disposed in the

housing and adapted for producing a stream of ozonated water from both the pressurized flow of water and the stream of ozone-containing gas.

Importantly, the apparatus further comprises a degas assembly disposed within the housing. The degas assembly functions to separate, collect and remove any undissolved ozone gas from the ozonated water. The ozonated water (with undissolved ozone removed therefrom) is then discharged from the degas assembly and eventually passed through an outlet on said housing as a safe, highly useful, pressurized stream or flow of ozonated water. This flow of pressurized ozonated water can be used for varied applications as described elsewhere herein, for example, as a sanitizing rinse material.

The separated undissolved ozone gas is passed to an ozone gas destruct assembly which is also disposed or provided within the housing. The ozone destruct assembly is adapted to receive and destroy the undissolved ozone gas separated in the degas assembly. More specifically, the ozone destruct assembly may utilize a two stage process involving heating the undissolved ozone and passing the heated undissolved ozone through a catalyst chamber to destroy the ozone, and preferably convert the ozone to oxygen (O_2) which can be safely vented from the apparatus into ambient air.

Preferably, the spray apparatus further comprises a pressure regulator assembly, in fluid communication with the water inlet, adapted to maintain the flow of water at a substantially constant pressure within the housing. The pressure regulator assembly may include a pump mechanism, for example, a pressure pump, capable of boosting the initial water pressure to a pressure sufficient to enable effective operation of the injector assembly, for example, the assembly venturi injector.

Preferably, the spray apparatus, in its entirety, is

sized and adapted to be manually portable. That is the spray apparatus preferably is sized and adapted to be effectively and conveniently moved from place to place for use by one or more adult human beings, more preferably by a single adult human being. The ozone generator, degas assembly, ozone destruct assembly and pressure regulator assembly, are all disposed or enclosed within the housing. The apparatus may include, or may be adapted to be mounted on, a wheeled base for facilitating mobility and manual transportation of the apparatus.

Each of the features disclosed herein can be used alone and in combination with one or more other such features. Each such feature and combination is within the scope of the present invention.

Brief Description of the Drawings

The objects and advantages of the present invention may be more clearly understood and appreciated with reference to the following detailed description and accompanying drawings.

Fig. 1 is a perspective view of a spray apparatus that produces an ozone/aqueous discharge stream in accordance with one embodiment of the invention.

Fig. 2 is a generally schematic illustration of an embodiment of the spray apparatus in accordance with the invention, showing an ozone generator, a degas separator, and an ozone destruct unit.

Fig. 3 is a plan view of some of the components of the embodiment shown in Fig. 2.

Detailed Description of the Preferred Embodiment

Turning now to Fig. 1, a spray apparatus 10, in accordance with the present invention is shown. Generally, the apparatus 10 is designed to receive an aqueous stream

(represented by arrow 12), for example a stream of water from a pressurized water supply, and to produce an ozone/aqueous stream 14 (hereinafter sometimes referred to as "ozonated water") useful for cleaning and disinfecting containers, products and other surfaces.

In the preferred embodiment shown, the spray apparatus 10 is compact and highly portable, enabling its use in facilities where access to equipment and passageways may be limited.

Preferably, the spray apparatus 10 is mobile, for example by means of a wheeled base 15, and is sized and adapted to be easily maneuvered through relatively narrow passageways, up and down ramps, and over hoses and cords, for example as is found in a typical agricultural or food processing environment.

Importantly, as disclosed further below, the spray apparatus 10 reduces or eliminates the possibility of ozone gas escaping the into the work environment and thus the risks associated with free ozone gas. Advantageously, therefore, the apparatus 10 is suitable for use in a variety of settings and facilities, even those frequented by humans and animals. For example, the apparatus 10 is useful in food processing plants, commercial livestock facilities, beverage bottling plants, and in wineries (for example for cleaning wine barrels), and many other settings where sanitizing and disinfecting of surfaces is necessary or beneficial.

Referring as well to Figure 2, the spray apparatus 10 is generally comprised of a housing 16 in which is disposed a pressure regulating system 18, an ozone generator 20, a degas system 22 and an ozone destruction system 30. The housing 16 is preferably made of stainless steel or other suitable material. The housing is preferably environmentally sealed by conventional means.

The aqueous stream 12 may be provided by a pressurized

water supply, for example a municipal water supply having a pressure of between approximately 20 psi and approximately 60 psi. The water initially enters the apparatus housing 16 through an inlet 24. The inlet 24 is preferably adapted to be directly connected, for example by a standard size water hose/conduit 25, to the water supply.

After being processed in the apparatus 10 as will be discussed hereinafter, the ozonated water discharge stream 14, having an ozone concentration sufficient to eliminate undesirable microorganisms, exits the housing 16 through an outlet 26 at approximately 32 psi and approximately 10 gallons per minute.

The ozone/aqueous stream outlet 26 is preferably connected to a flexible hose 28 which may have attached thereto a flow restrictor or spray nozzle 30 for dispensing the ozone/aqueous stream 14 as a controllable spray of sanitizing fluid at a pressure suitable for the intended application.

Referring now specifically to Fig. 2 and 3, the pressure regulating system 18 is designed to regulate the pressure of the incoming aqueous stream. The pressure regulating system 18 maintains a substantially constant pressure of water for processing despite fluctuations in pressure of the incoming stream through the inlet 24.

For example, the pressure regulating system 18 may include a pressure regulating valve 40, a check valve 42, and a pressure pump 44. A line 48 places the inlet 24 in fluid communication with an intake 50 of the pressure pump 44.

Functionally installed in line 48 is the pressure regulating valve 40 and the check valve 42, with the check valve being downstream of the regulating valve 40.

The pressure reducing valve 40 reduces the aqueous stream 12 pressure to below the low end of the water supply pressure range. For example, the pressure regulating valve

40 may be adapted to reduce the initial pressure of the aqueous stream 12 to between approximately 10 psi to approximately 15 psi. The incoming aqueous stream 12 is controlled to a maximum setting in order to stabilize initial pressure of the aqueous stream and prevent over-pressurization of internal components of the apparatus 10.

The check valve 42 is provided in line 48 to prevent backflow of the aqueous stream 12 in apparatus 10 to the water supply. Another function of the check valve 42 is discussed below in conjunction with the bypass valve 46.

The pressure pump 44 may have a capacity of approximately 10 gallons per minute at approximately 110 psi, in order to provide sufficient pressure of water for injection of ozone gas in venturi injector 60. As shown, the pressure pump 44 has an intake 50 in fluid communication with line 48, and a discharge 52 in fluid communication with pressurized water line 54.

The pressure regulating system 18 preferably includes a bypass arrangement 56 for allowing substantially unrestricted flow capacity to the pressure pump 44. For example, at least a portion of the aqueous stream discharging the pressure pump 44 may be recirculated through a bypass line 57 to the pressure pump intake 50. A bypass valve 58 is shown installed in the bypass line 56 for controlling the rate and amount of water being recirculated. The bypass arrangement 56 enables the pressure pump 44 to operate at full capacity regardless of variations in the aqueous stream 12 flow or variations in the flow of the ozone/aqueous discharge stream 14.

The aqueous stream discharging from the pressure pump 44 along line 54 is injected with ozone gas from the ozone generator 20 to produce an ozonated aqueous stream (i.e. ozone dissolved in water) in line 59. The ozone dissolved in the discharge stream 14 is preferably greater than approximately 0.5 ppm, and more preferably, is greater than

about 1 ppm. By having the dissolved ozone in the discharge stream 14 be greater than about 1 ppm, the ozone concentration is effectively high enough to kill microorganisms such as bacteria, virus, mold, spores, yeast, mildew and fungus.

Effective dissolution of ozone gas in the aqueous stream can be accomplished by means of a venturi injector 60, in which the pressurized water is "injected" with ozone gas to provide mixing and dissolving of the ozone gas in the water. A back pressure regulator 62 is shown installed in line 59 which may be included to control pressure downstream of the venturi injector 60, allowing for optimal injector operation.

Preferably, the venturi injector 60 provides a source of suction through line 64 for vacuum operation of the ozone generator 20. Thus, the ozone gas is not injected into the water stream under pressure. The pressure in the ozone generator may be held at a substantially constant about 3 inches Hg to about 5 inches Hg regardless of other flow considerations. Importantly, by operating the ozone generator 20 under negative pressure, the possibility of any substantial quantity of ozone escaping into the atmosphere is prevented.

A pressure test port 71 may be installed in line 59 to test pressure of the aqueous stream exiting the venturi injector 60.

The ozone generator 20 may be comprised of a conventional ozone generator. Preferably, however, the generator 20 is a corona discharge ozone generator that is relatively small in size that will produce a high concentration of ozone gas in oxygen, for example an ozone gas stream of about 5g/hour. Dissolved in a 10 gallon per minute water stream, this will produce a ozonated water stream of about 2+ ppm ozone, which is sufficient to overcome nominal "clean" water ozone demand with about 1+

ppm residual.

Upon a user opening the spray valve 30, flow is detected in the venturi injector 60 by a flow switch 72 which then activates the pump 44 and the ozone generator 20. This arrangement ensures that ozone is only being generated and the pressure pump is only operating when the venturi injector 60 is operating.

Advantageously, the present invention 10 is structured to destroy undissolved ozone gas exiting the venturi injector 60. More specifically, the ozonated aqueous stream exiting the venturi injector 60 is passed into the ozone degas system 22 where undissolved ozone gas is separated and removed from the ozonated stream. The undissolved ozone gas is eventually directed to the destruct unit 30. The resulting ozonated water, having undissolved ozone gas removed, is passed from the degas assembly 22 through line 82, and to the outlet 26 of the apparatus 10. The degas separator 22 is designed to receive the ozone/aqueous stream though an inlet port 214 and discharge the degassed ozone/aqueous discharge stream through an outlet port 216 at substantially the same pressure.

The degas separator 22 may be a degas separator similar in construction to a degas separator assembly sold by Del Industries, Inc. under the trade name DVX - 2400, or DVX -3600.

The degas/separator assembly 22 and the ozone destruction assembly 30 (hereinafter sometimes referred to as the "ozone destruct unit"), may be more clearly understood with specific reference to Fig. 3. An undissolved ozone gas stream exits the degas assembly 22 through a gas exit port 222, and is directed into the ozone destruction assembly 30 through line 224.

Preferably, the ozone destruction assembly 30 provides

a two stage ozone destruction process. More specifically, the destruct unit 30 is adapted to provide both thermal and catalytic destruction of the ozone gas.

For example, the ozone destruction assembly 30, hereinafter sometimes referred to as the "ozone destruct unit" may include a housing 302 with a gas entrance inlet 304. Within the housing 302 is a heating element 316 adapted to be connected to a 120 V power source for example, and a chamber 324 containing a catalyst (not shown) capable of converting the undissolved ozone into oxygen. In a preferred embodiment of the invention, the catalyst is manganese dioxide, but other embodiments of the invention may use other suitable ozone destruct catalysts, such as activated carbon. The undissolved ozone gas is directed through the inlet 304 and is heated and dried by the heating element 316. The heated gas is directed through the catalyst chamber 324 prior to being discharged as an oxygen stream (O_2) through an outlet 326. Heating of the gas stream provides for a more rapid, efficient rate of ozone destruction by the catalyst. In addition, the heating inhibits condensation formation in the destruct unit 30. Rapid, efficient destruction of undissolved ozone is important in light of the high concentration of ozone being produced by the corona discharge generator 20. The destruct unit 30 may be similar in construction to an ozone destruct unit sold by Del Industries, Inc. under the trade name DD-0100.

It is desirable to prevent water from reaching the catalyst in the catalyst chamber 324. Accordingly, means are preferably provided for preventing water from entering the ozone gas line 224. A ball valve arrangement (not shown) may be provided for closing the gas line 224 in the event a level of the ozone/aqueous liquid in the degas assembly 22 approaches the outlet 222. In addition, a

surface turbulence reducer 240 may be provided in the degas system 22. The reducer 240 may be comprised of a perforated disk extending laterally across the interior of the degas unit 22.

Other embodiments of the invention may have other suitable arrangements. For example, a spray apparatus may have multiple outlets 26 to facilitate the use of multiple spray nozzles 30. Further, a spray apparatus may have parallel or serial process systems therein, such as two ozone destruct systems connected in parallel or in series. Still further embodiments of the invention may be fixed mounted to a skid or a non-movable structure. Additional embodiments of the invention may be automated such that the spray nozzle need not be manually operated.

While this invention has been described with respect to various specific examples and embodiments, it is to be understood that the invention is not limited thereto and that it can be variously practiced within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A spray apparatus for combining ozone into an aqueous stream having an initial pressure comprising:

a pressure regulating system adapted to be in fluid communication with the aqueous stream at the initial pressure and to discharge the aqueous stream at a post regulating system pressure via a pressure pump;

an ozone generation system adapted to receive the aqueous stream at the post regulating system pressure, generate and introduce ozone gas into the aqueous stream via an ozone generator functionally connected to an injector, and to discharge an ozone/aqueous stream at a discharge pressure;

a flow indication system adapted to turn on the ozone generator and the pressure pump when the aqueous stream is flowing through the injector; and

an ozone destruct system adapted to receive the ozone/aqueous stream, and to separate and destroy uncombined ozone gas from the ozone/aqueous stream, and to discharge an ozone/aqueous discharge stream through an ozone destruct system port, whereby the spray apparatus is adapted such that the aqueous stream flows through the injector only when the ozone/aqueous discharge stream is discharging through the port.

2. The spray apparatus of Claim 1, wherein the pressure regulating system further comprises:

a pressure regulating valve adapted to receive the aqueous stream at an incoming pressure and to discharge the aqueous stream at a pressure lower than the incoming pressure, wherein an intake of the pressure pump is adapted to receive the lower pressure aqueous stream;

a bypass line comprising an opening in fluid

communication with a discharge of the pressure pump and another opening in fluid communication with the intake of the pressure pump;

a bypass valve functionally in the bypass line and adapted to enable a bypass portion of the aqueous stream to flow to the intake of the pressure pump from a discharge of the pressure pump; and

a check valve functionally upstream of the bypass line and adapted to enable the aqueous stream to flow downstream through the check valve but not upstream through the check valve, wherein downstream is a direction from the pressure regulating valve to the pressure pump.

3. The spray apparatus of Claim 1, wherein the pressure pump is adapted to pump at least about 10 gallons per minute of the aqueous stream at a pressure of at least about 110 psi.

4. The spray apparatus of Claim 1, wherein the flow indication system comprises a flow switch functionally in a line having an opening in fluid communication with the pressure regulating system and another opening in fluid communication with an inlet of the injector.

5. The spray apparatus of Claim 1, wherein the ozone generation system further comprises a back pressure regulator installed downstream of the injector and adapted to provide substantially constant pressure to an outlet of the injector.

6. The spray apparatus of Claim 5, wherein the injector is a venturi injector adapted to inject an ozone gas stream from the ozone generator into the post regulating system pressure aqueous stream.

7. The spray apparatus of Claim 6, wherein the back pressure regulator is adapted to enhance venturi injector operation.

8. The spray apparatus of Claim 7, wherein the back pressure regulator, the venturi injector, and the ozone generator are adapted to operate such that the ozone generator has a pressure range of about 3 inches Hg to about 5 inches Hg, thereby reducing the ability of ozone gas from the ozone generator to discharge other than to the venturi injector.

9. The spray apparatus of Claim 1, wherein the ozone generator is a corona discharge ozone generator.

10. The spray apparatus of Claim 1, wherein the zone destruct system further comprises:

a degas separator adapted to collect uncombined ozone from the ozone/aqueous stream, to discharge an uncombined ozone gas stream from the collected undissolved ozone, and to discharge the ozone/aqueous discharge stream; and

an ozone destruct unit adapted to receive the uncombined ozone gas stream, to convert the uncombined ozone gas stream into oxygen via a catalyst, and to discharge the oxygen.

11. The spray apparatus of Claim 10, wherein the catalyst is manganese dioxide.

12. The spray apparatus of Claim 10, wherein the degas separator comprises a tank having an ozone/aqueous stream inlet in a middle portion of the tank, a tank bottom comprising the ozone destruct system port, an uncombined

gas stream outlet at a top of the tank, and a surface turbulence reducer disposed between the uncombined gas stream outlet and the ozone/aqueous stream inlet.

13. The spray apparatus of Claim 12, wherein the degas separator further comprises a valve assembly adapted to discharge the uncombined ozone gas stream when ozone/aqueous liquid in the tank is below a predetermined level and to cease discharging the uncombined ozone gas stream when the zone/aqueous liquid level is at or above the predetermined level, thereby inhibiting the ozone/aqueous liquid in the tank from exiting through the uncombined gas stream and coming into contact with the catalyst in the ozone destruct unit.

14. The spray apparatus of Claim 10, wherein the ozone destruct unit comprises:

an uncombined ozone gas stream inlet, a heater downstream of the uncombined ozone gas stream inlet adapted to heat the uncombined ozone gas stream; and

a catalyst chamber adapted to receive the heated uncombined ozone gas stream and to enable the heated uncombined ozone gas stream to come into contact with the catalyst disposed therein, thereby converting the heated uncombined ozone gas stream to oxygen, and to discharge the oxygen stream.

15. The spray apparatus of Claim 1, further comprising a discharge valve adapted to be connected to the ozone destruct system port and to restrict or eliminate the discharge of the ozone/aqueous discharge stream through the port by operation of the discharge valve.

16. The spray apparatus of Claim 15, wherein the

discharge valve comprises a manually operated spray nozzle.

17. The spray apparatus of Claim 16, wherein the spray nozzle is adapted to have a flow and pressure capacity substantially matched to a flow and pressure capacity of the pressure pump and the injector.

18. The spray apparatus of Claim 15, further comprising a flow restrictor disposed between the ozone destruct system port and the discharge valve and adapted to enable a flow of the ozone/aqueous discharge stream to be matched to a flow and pressure capacity of the pressure pump and the injector.

19. The spray apparatus of Claim 1, wherein the pressure regulating system, the ozone generation system, the flow indication system, and the ozone destruct system are disposed in a housing.

20. The spray apparatus of Claim 19, wherein the housing is portable.

21. The spray apparatus of Claim 20, adapted to provide greater than about 0.5 ppm uncombined ozone in the ozone/aqueous discharge stream.

22. The spray apparatus of Claim 20, adapted to provide greater than about 1 ppm dissolved ozone in the ozone/aqueous discharge stream.

23. An ozonated water spray apparatus comprising:

a housing;

an inlet on said housing, the inlet adapted to receive a flow of water from a pressurized water supply;

an ozone generator, disposed within the housing and adapted to produce an ozone-containing gas stream;

a venturi injector, adapted to receive both the pressurized flow of water and the ozone-containing gas stream from the ozone generator, and adapted to produce and discharge a stream of ozonated water;

a degas assembly disposed within the housing and adapted to receive the stream of ozonated water from the venturi injector and adapted to separate any undissolved ozone from the ozonated water and discharge a stream of ozonated water having undissolved ozone removed therefrom;

an ozone gas destruct assembly disposed within the housing and adapted to receive the undissolved ozone gas from the degas assembly and to destroy the undissolved ozone;

an ozonated water discharge line connected to the degas assembly adapted to receive the stream of ozonated water discharged from the degas assembly; and

an outlet on said housing adapted to discharge a pressurized flow of ozonated water from the apparatus.

24. The apparatus of claim 23 wherein the ozone destruct assembly includes both a heating element adapted to heat the undissolved ozone and a catalyst chamber including a catalyst capable of converting the undissolved ozone into oxygen.

25. The apparatus of claim 24 wherein the catalyst comprises manganese dioxide.

26. The apparatus of claim 23 further comprising a pressure regulator assembly, in fluid communication with the inlet, adapted to maintain the flow of water at a substantially constant pressure within the housing.

27. The apparatus of claim 23 wherein the apparatus is sized to be manually portable.

28. The apparatus of claim 27 further comprising a wheeled base, mounted to the housing, for facilitating manual portability of the apparatus.

29. The apparatus of claim 23 wherein the ozone generator is a corona discharge ozone generator.

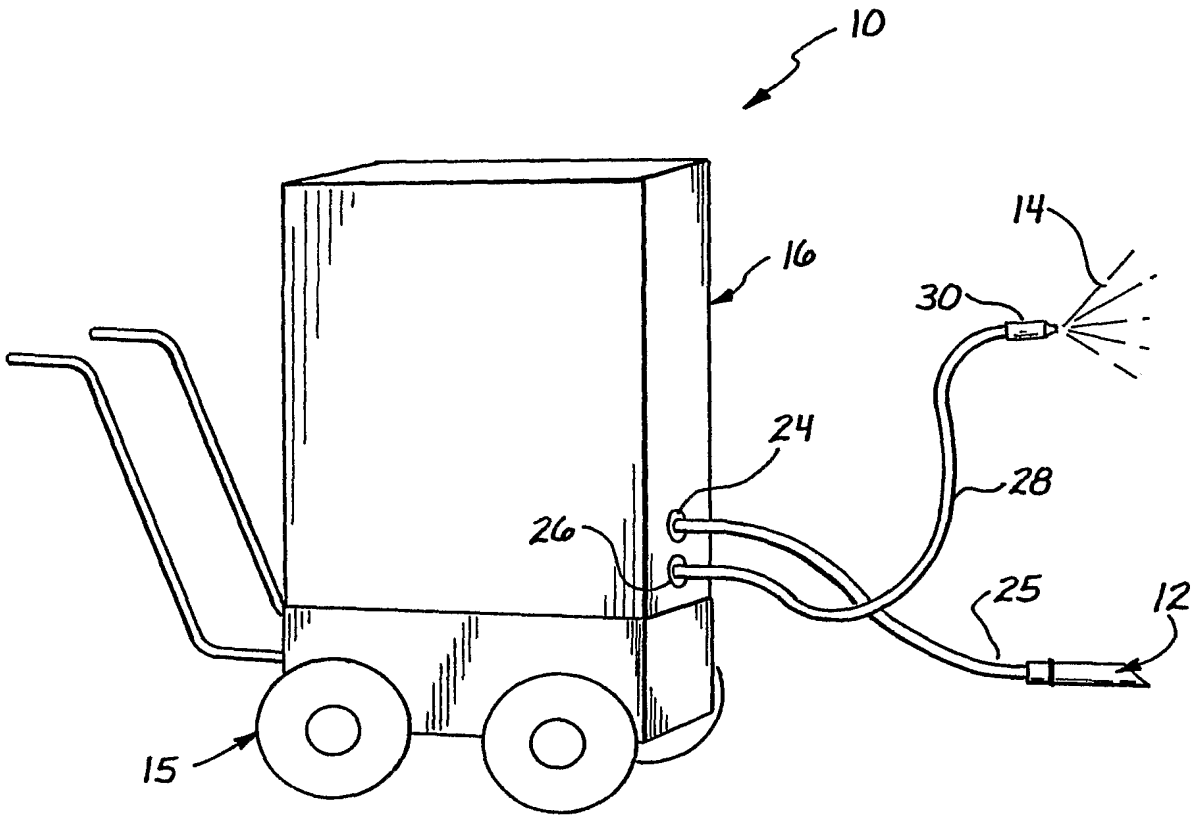

FIG. 1

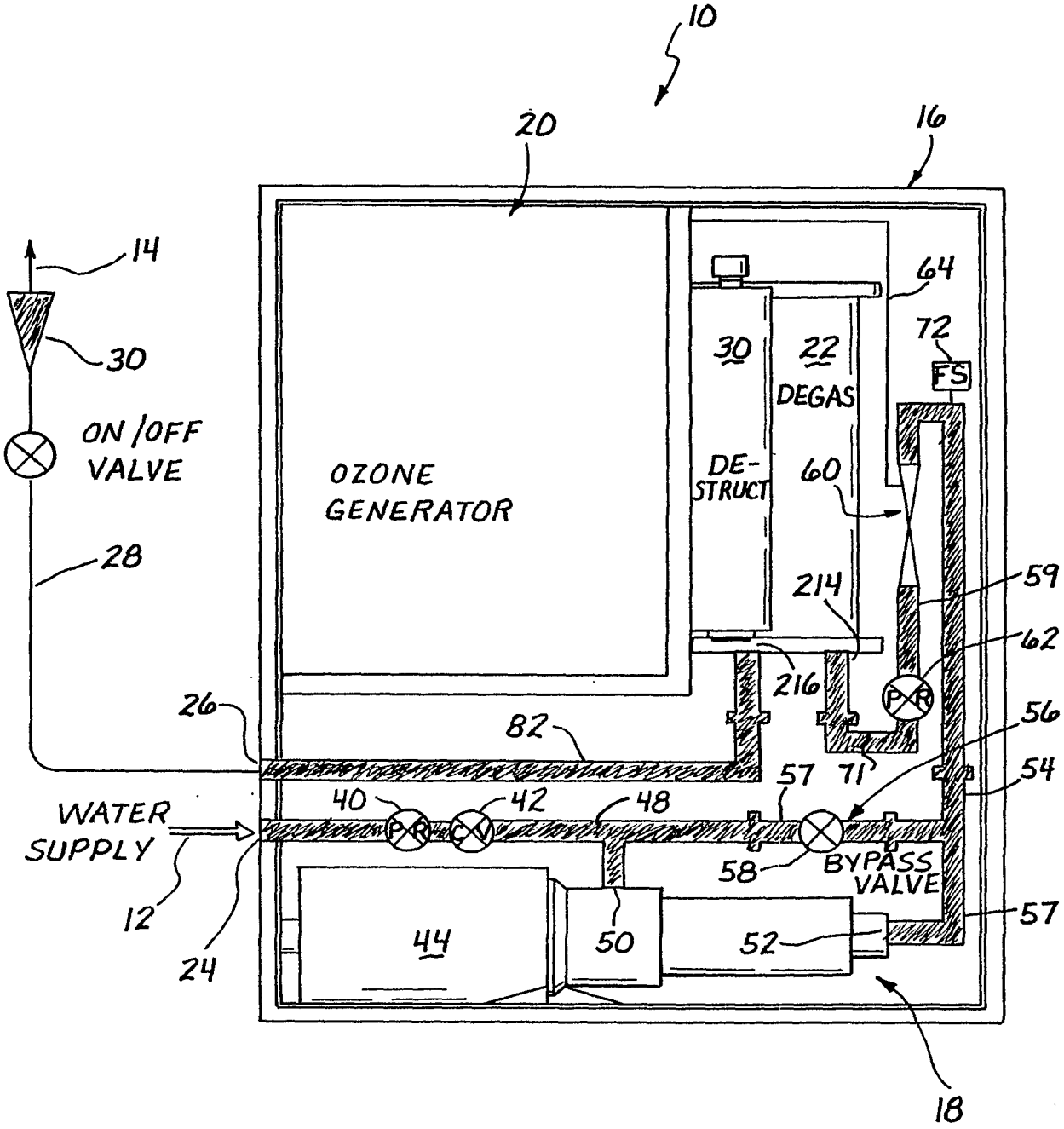
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FIG. 2

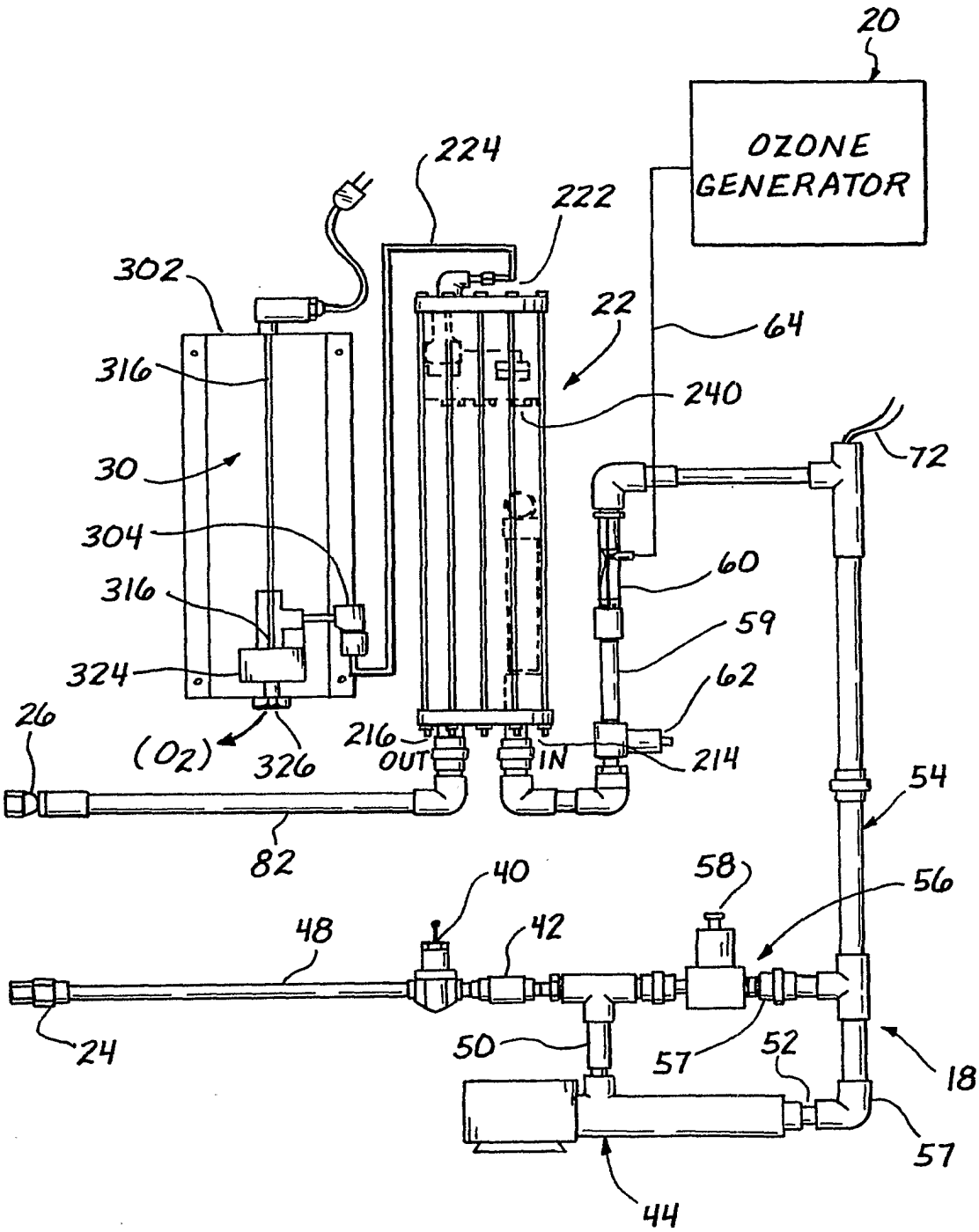
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FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/09830

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B05B 7/26
US CL : 239/310

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : Please See Continuation Sheet

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 6,132,629 A (BOLEY) 17 October 2000 (17.10.2000), see entire document.	1
Y,P		1-17, 19-22
Y	US 5,674,312 A (MAZZEI) 07 October 1997 (07.10.1997), see entire document.	1-17, 19-26
Y	US 5,032,365 A (JHA et al) 16 July 1991 (16.07.1991), see entire document.	2, 26
Y	US 5,433,866 A (HOPPE et al) 18 July 1995 (18.07.1995), see entire document.	9, 15-17
Y	US 4,143,118 A (LAING) 06 March 1979 (06.03.1979), see entire document.	10-14, 24, 25, 29
Y	US 4,967,960 A (FUTRELL) 06 November 1990 (06.11.1990), see entire document.	19-29
A	US 2,203,980 A (BURT) 11 June 1940 (11.06.1940), see entire document.	2
A	US 5,250,177 A (CHO) 05 October 1993 (05.10.1993), see entire document.	1-17, 19-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 June 2001 (26.06.2001)	06 AUG 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer David A. Scherbel Telephone No. (703) 308-1113

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/09830

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claim Nos.: 18
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Please See Continuation Sheet

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/09830

Continuation of Box I Reason 2: Claim 18 objected to as lacking clarity under PCT Rule 66.2(a)(v) because practice of the claimed invention is not enabled as required under PCT Rule 5.1(a) for the reasons set forth in the immediately preceding paragraph.

The specification does not appear to disclose a flow restrictor.

Continuation of B. FIELDS SEARCHED Item 1: 239/310, 311, 312, 412, 417.5; 261/DIG75, DIG42; 96/193, 194; 422/173, 177, 120, 121, 122; 137/565.35, 565.13, 565.16; 417/43, 307, 440, 295, 441